

APA Consortium

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Scope / content of this presentation

APA TDR walkthrough:

- What we have for our first TDR draft on **21/12/2018**
- What is open / ongoing for the **02/2019** draft
- What we will add for our final TDR submission in the summer

Outlining what the consortium is doing to achieve these goals

APA design (i)

- Design is a minor evolution wrt ProtoDUNE
 - Basic parameters (total & active area, 35.7° U/V wires layer angle to vertical, 4.79/4.67mm wire pitch, 4.75mm wire plane spacing, 0.5mm tolerance on the previous, number of wires, 150 μ m Be/Cu wire) unchanged
 - Full DUNE MC CPV sensitivity studies demonstrated that 3mm wire spacing and 45° U/V wire angle do not impact the physics reach
 - 0.5mm tolerances derived from electric field simulations
 - Effects from wire plane spacing deviations will be studied in ProtoDUNE-SP real data
 - Wire tension: ProtoDUNE APA-to-APA variations will allow to study any effects for tensions in the region 4.5-7.5N on data quality
 - We use 6N as the baseline for DUNE, TBC after ProtoDUNE analysis
 - No wire broke in cool-down or during operation

APA design (ii)

Support frame modifications wrt ProtoDUNE:

- Moving from 4x3 inches to **4x4 inches** to allow EC cables routing through the vertical frame sections
- Introduction of joining mechanism to support the lower APA in a pair from the upper one (using composites for electrical isolation)
- Adapting details (e.g. frame lifting points) for ease of handling and informed by FEA
- **Design** largely done
- **FEA** ongoing
- Some minor details to be finalised
- **60% design review** in February

APA design (iii)

Grounding wire mesh: new scheme replacing the ProtoDUNE one-piece mesh with pre-fabricated welded stainless wire frames

- Saves construction time & cost
- Better controlled grounding plane quality
- Already used in APA #7 (nearing completion at Daresbury)

New: PD wires running between the two wire mesh planes along the frame, required features added to the frame design

Electron diverters to minimise charge loss between APAs:

- ProtoDUNE is equipped with electron diverters in beam-side drift
- modified design is ready for DUNE, electric field simulations done
- Final decision and design TBC depending on ProtoDUNE results

APA wiring

The wiring machine has been improved to avoid moving the APA from the machine to a process cart and back multiple times

- Time & cost savings
- Already used in APA #7 construction

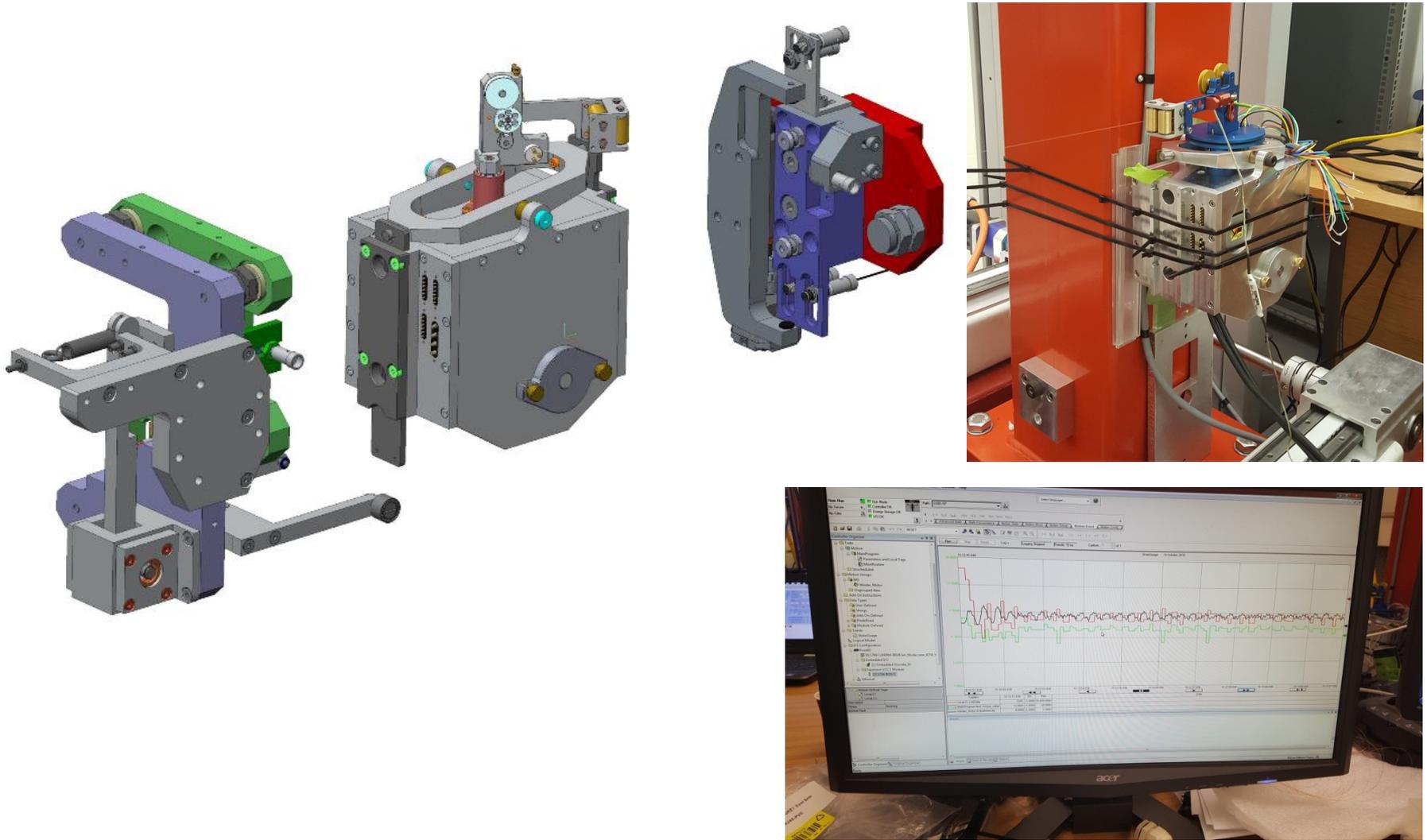
Wire-tension control implemented in new wiring head

- Better tension uniformity
- Automatic capture of individual wire tension
- Time & cost savings through sampling tension QC, TBC
- New head constructed, undergoing extensive commissioning and qualification tests before use on an actual APA

APA #7 with the mesh frames on the modified winding machine at Daresbury



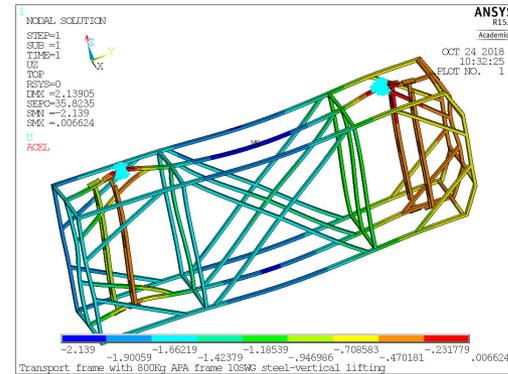
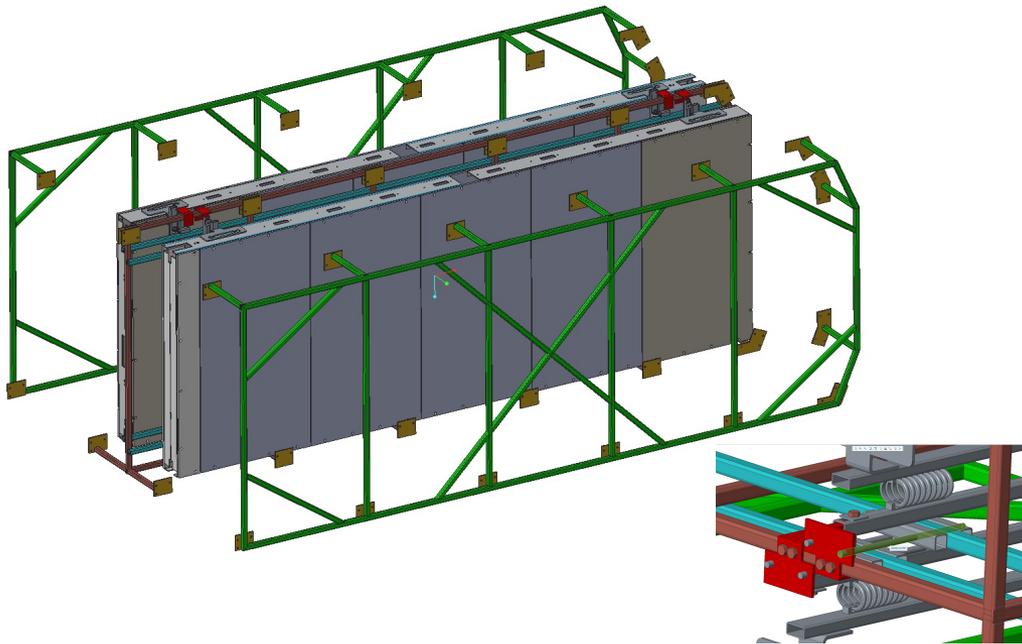
Winder head with active tension control



APA transportation (i)

A dedicated frame system is developed at Liverpool that will carry a pair of APAs from assembly facility to the underground assembly area. Drawing on ATLAS Endcap-C silicon detector.

Being developed according to a “requirements document” based on ProtoDUNE experience and TC installation related guidance.



APA transportation (ii)

- Transportation of US APAs will be by truck (or train)
- From the UK we will use RO/RO shipping from Liverpool to NY
- We have already first quotes from transportation companies that we have used for transportation of detectors inside the US and from the UK to Europe, US and Japan
- A particular challenge is that the 2 APA assembly will not fit into any container
- We are working on optimising the scheme with dedicated meetings and talking to the companies
- The frame support systems will be used throughout
- Packaging in one-use crates or the final special protection shells for going underground is still TBC

Construction facilities, work distribution

- APA assembly:
 - Daresbury 150 APAs
 - U. Chicago, Yale, PSL 150 APAs
- Other activities will be distributed to university groups:
 - Procurements, QC oversight in industry (frames, mesh)
 - Combs & boards
- In the UK the distribution between groups is described in the funding proposal to STFC, to be reviewed in December/January
- In the US there are dedicated ongoing meetings involving all groups
- UK/US distribution of deliverables:
 - agreed in the summer
 - Some details at the 1% level being discussed currently

QA/QC

- The consortium is developing the elements and strategy, we will methods and tools from the central DUNE QA team
- **Frames**: dimensions & flatness will be checked at construction (industry or institute) and upon reception at assembly facility. Use of photogrammetry and laser tracking systems.
- **Wire tensions**: dedicated Task Force in action currently
 - Adding automation and multiple lasers to the protoDUNE "pluck and listen" system as the baseline
 - Developing electrical system, may require some card modifications, would be faster and offer more flexibility at ITF, underground
 - Analyzing ProtoDUNE data searching for correlations to noise and signal characteristics vs tension

ESH

- We have a working baseline from ProtoDUNE that satisfies CERN, PSL, STFC rules as appropriate
- We are developing standard rules, e.g. for access near the winding machines, for all facilities
- Our processes will comply with central DUNE and (any additional) local requirements

Next prototyping steps

- protoDUNE-style **APA #7** is made at Daresbury for CE tests at CERN
- **2 APA frames** will be made at PSL to test linking and hanging at Ash River
 - CE and PD cabling scheme will be fully tested also
- **3 final-design, pre-production APAs** will be made (1 UK, 2 US) and sent to CERN for installation in ProtoDUNE-SP-II

ProtoDUNE inputs

- We have an excellent "lessons learned" from ProtoDUNE integration and installation
- We are preparing the same from ProtoDUNE production
- We have people analysing ProtoDUNE data and also on their correlation with characteristics / QC data of the elements
- Following the ProtoDUNE Analysis Workshop in late January we will determine the definite list of analysis results that will be available for our TDR and the delivery timeline

Schedule

- A full schedule has been prepared for the US for the director's and DOE reviews (in P6)
- APA production start and duration is determined by:
 - Spending profile in the national funding proposals
 - Detailed production sequence and duration of each step as determined over the summer between Daresbury, PSL, consortium leadership and UK, US leadership
- The goal is to start full production in the UK in summer 2020 and in the US in summer 2021
- The final underground steps depend on the overall DUNE-LBNF schedule, the consortium will ensure that all required APAs are produced in time so we are not in the critical path of the FD SP volumes

Cost

- We have a full cost estimate according to NCG instructions
- Core costs (procurements and other contracts) and manpower type and amount/type for each step have been determined over the summer with input from PSL and Daresbury and reasonably conservative assumptions for gains from improved machines and procedures
- First submission to the NCG generated a positive response
- We are working on the details to reach the level required for the DOE review in January

Risks

- We have an initial risk register
- This is evolving following developments in overall DUNE FD schedule and integration and installation procedures
- We are following the lead from DUNE/TC in this area

Summary

- The APA consortium is working hard on many parallel fronts to deliver a TDR in the set time frame
- We don't have time to spare but we don't foresee anything critically late either
- We welcome your comments and guidance